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Effects of Triticale-Based Diets on Finishing Pig Performance and Pork Quality in Deep-Bedded Hoop Barns

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Summary and Implications

Effects of triticale-based diets on finishing pig performance and pork quality in deep-bedded hoop barns were evaluated. Triticale is a synthetic small grain resulting from a cross between durum wheat and rye. The study consisted of four trials: two in winter (November 2003 through March 2004) and two in summer (May 2004 through September 2004) at the ISU Western Research and Demonstration Farm, Castana, IA. Each trial consisted of six pens of ten pigs (five barrows, five gilts) in three small-scale hoop barns (6.0 × 10.8 m). Pens were randomly assigned one dietary treatment: 1) corn-soybean meal control, 2) 40% Trical 815 triticale diet (by weight) or 3) 80% Trical 815 triticale diet (by weight). The 40 and 80% triticale diets had corn and soybean meal added. Animals had *ad libitum* access to feed and water during the study. Pigs were started on experiment at approximately 72 kg and fed for 49 d. At the end of each trial all pigs were scanned for backfat thickness and loin muscle area. Barrows from one winter and one summer trial were evaluated for meat and fat quality and sensory evaluation of pork. End weights and ADG were greater during the winter than summer (treatment × season interaction $P < 0.01$) and decreased as triticale inclusion increased ($P < 0.001$). Feed intake was similar. Pigs fed the control diet had the greatest G:F, those fed the 80% triticale diet had the least, with pigs fed the 40% triticale diet having intermediate G:F. During the summer, pigs fed the control diet had more BF ($P < 0.05$) than those fed the triticale diets. Also during summer, pigs fed the control diet had the largest loin muscle area (LMA) ($47.5 \pm 1.72 \text{ cm}^2$); pigs fed the 40% triticale diet had intermediate LMA ($45.5 \pm 1.72 \text{ cm}^2$) and those fed the 80% triticale diet had the smallest LMA ($43.4 \pm 1.73 \text{ cm}^2$). Dietary treatment had no effect on carcass weight, BF, LMA, percentage lean of barrows or sensory evaluation or fatty acid profile of loin chops. Ultimate pH was higher ($P < 0.001$), percentage loin purge was less ($P < 0.05$) and shear force (kg) was less ($P < 0.05$) during summer than winter. Total monounsaturated fatty acids (MUFA) were greater ($P < 0.05$) and total PUFA in loins were less ($P < 0.01$) during the winter than summer. Replacing corn with triticale in finishing pig diets in hoops slightly decreased growth performance, but did not affect pork quality.

Increasing the amount of triticale in finishing pig diets decreased dietary soybean meal and dicalcium phosphate levels. This may reduce dietary costs. However, pigs fed triticale had 10% less average daily gain and 13% poorer feed conversion at the greater inclusion rate (80% of the diet). This may offset the potentially lower dietary costs. Triticale can be fed to pigs without compromising pork or fat quality. There was no difference in pork eating quality from pigs fed corn-based or triticale-based diets, according to a trained sensory evaluation panel. Further research on triticale-based swine diets is warranted. Triticale-based diets in deep-bedded hoop barns should be evaluated when dietary fat is added, as finishing pig performance may be enhanced. An economic analysis should be conducted on utilization of triticale as a feedstuff in swine diets fed to finishing pigs in deep-bedded hoop barns. From the results of this study, triticale has potential as a feed grain crop in integrated crop and livestock enterprises in the Midwest U. S.

Introduction

Triticale is a synthetic small grain that results from an intergenetic cross between durum wheat and rye. Triticale has more crude protein and an amino acid profile that more closely matches the needs of the finishing pig than corn. Utilization of triticale as an ingredient in swine diets will decrease the amount of soybean meal needed to meet the amino acid needs of the pig, compared to corn-based diets. There have been conflicting results on the effects of feeding triticale to finishing pigs. Some studies reported similar pig performance when triticale replaced corn as the dietary grain source, while others have shown decreased performance.

Alternative swine production systems have become increasingly popular among pork producers and consumers. Producers are attracted to alternative production systems for many reasons including niche market access, animal welfare concerns, low-capital investments, versatility, health concerns of the producer and environmental considerations. One such alternative swine production system is deep-bedded hoop barns or hoops. Hoops costs per initial pig space are roughly one-third that of confinements. Studies have shown that pigs perform similarly in hoops and confinement.

Triticale is being considered as a potential third crop in the Midwest. In order to become adopted by producers, an additional crop must meet two important criteria. The crop must have a readily accessible market and be profitable to produce. Triticale has shown potential as a feedstuff in swine diets. Producers who may find this to be an attractive

crop may also raise swine in an alternative swine production system. The objective of the present study was to evaluate the effects of triticale-based diets in deep-bedded hoop barns on finishing pig performance and pork quality.

Materials and Methods

Animals and dietary treatments

Finishing pigs ($n = 240$) were used to evaluate the effects triticale-based diets fed in hoop barns had on pig performance, meat and fat quality and pork sensory attributes. The study consisted of four trials: two in winter (November 2003 through March 2004) and two in summer (May 2004 through September 2004) at the Iowa State University Western Research and Demonstration Farm, Castana, IA.

Each trial consisted of six pens of ten pigs (five barrows and five gilts) in three small-scale hoop barns (6.0×10.8 m). Each test pen had one water space and two feeder spaces. The pigs were started on experiment at approximately 72 kg and fed for 49 d. A two-week adjustment period was allowed for adaptation to triticale diets and experimental pens. Pens were assigned one of three dietary treatments: 1) corn-soybean meal control (0% triticale), 2) 40% Trical 815 triticale diet (by weight) or 3) 80% Trical 815 triticale diet (by weight). The 40 and 80% triticale diets had corn and soybean meal added. All diets were ground with a hammer mill through a 0.64 cm screen and presented in meal form. Composition and calculated analysis of experimental diets are given in Table 1. Animals had *ad libitum* access to feed and water during the study. At the end of each trial, all pigs were individually scanned for backfat and loin area by a certified technician with an ultrasound.

Proximate analysis, amino acid profile, and mycotoxin testing of triticale were performed at the University of Missouri, Columbia, MO. Triticale straw was used as bedding in the deep-bedded hoop barns.

Carcass Measures, Sensory Evaluation

Barrows from one winter and one summer trial were used to evaluate carcass traits, pork quality and pork sensory attributes. Barrows were transported to Swift and Co., Marshalltown, IA for processing. After slaughter and chilling, carcass traits were evaluated by trained personnel. These data included carcass composition traits, objective color measurements, and 22 h pH measured at the 10th rib. Subjective firmness of the loin was scored on a scale from 1 to 5, with higher values indicating greater firmness. Loins were evaluated at the ISU Sensory Evaluation Lab. Following a storage period, each vacuum package was opened and both the loin and the amount of purge in the bag were weighed to determine loin purge percentage. Minolta color measures were taken on a piece of loin backfat removed from the loin. Japanese color score was determined from one chop taken from the center of the loin. Two chops were removed from the center of the loin and one was

placed in a Ziploc bag for the evaluation of chop purge. The other chop was used for determination of marbling (% fat) by ether extraction. Two other chops were removed from the center of the loin and simultaneously broiled. Cooking losses were calculated from weights taken before and after broiling and expressed as a percentage. Instrumental measurement of tenderness of one broiled chop was evaluated using shear force. Sensory evaluation of the remaining broiled chop was performed using a trained professional panel. A 50 g sample of each loin was used for chemical analysis.

Chemical analysis

Dry matter percentage of the chop was determined using a standard dry matter procedure. Lipid percentage of the chop was determined using the wet tissue Folch lipid extraction method.

Statistical analysis

Data were analyzed using the mixed model of SAS. The experimental unit was a pen of pigs. Pen to pen variability was used to test effects of treatment, season, and treatment \times season interaction.

Results and Discussion

Triticale Analysis

The Trical 815 triticale in the present study had no detectable mycotoxins. Results of amino acid analysis (Table 2) show Trical 815 triticale had less amino acid content than the NRC values for triticale. However, when compared to the NRC values for amino acid content of corn, Trical 815 triticale had greater contents of all amino acids except leucine. Lysine content was determined to be 42% greater in Trical 815 triticale than corn (0.37 vs. 0.26%, respectively), according to analysis and NRC values.

Newer triticale cultivars are higher yielding, with plumper grain of heavier test weight and greater starch content. Selection of these traits has lowered the protein content of the grain. Although the lysine content in Trical 815 triticale was slightly less than that of older triticale varieties, the 40% triticale diet had 10.7% less soybean meal than the control diet and the 80% triticale diet had 25.3% less soybean meal than the control diet.

Growth Performance

During the summer, pigs fed the 80% triticale diet had lighter ($P < 0.05$) start weights than those receiving the control or 40% triticale diet (Table 3). There were no differences in start weights for pigs during the winter. End weights and ADG were more during the winter than summer (treatment \times season interaction; $P < 0.01$) and decreased as triticale inclusion increased ($P < 0.001$). No differences in ADFI between treatments were observed. There tended ($P = 0.10$) to be more feed consumed during the winter than summer. Pigs receiving the control diet had the greatest G:F. Pigs receiving the 80% triticale diet had

the least G:F and those receiving the 40% triticale diet were intermediate. This was observed during both the summer and winter. During the summer, pigs fed the control diet had more backfat (BF) ($P < 0.05$) than those fed the 40 or 80% triticale diets. There were no differences in BF during the winter. During the summer, pigs fed the control diet had the largest loin muscle area (LMA) ($47.5 \pm 1.72 \text{ cm}^2$), pigs fed the 40% triticale diet had intermediate LMA ($45.5 \pm 1.72 \text{ cm}^2$) and those fed the 80% triticale diet had the smallest LMA ($43.4 \pm 1.73 \text{ cm}^2$). Three pigs died during the study, one from each dietary treatment.

End weight and ADG of finishing pigs decreased ($P < 0.001$) as triticale increased in the diets. However, feed intake was similar between treatments. The 80% triticale diet had 4.8% less metabolizable energy (3160 vs. 3320 kcal/kg) than the control diet, while the 40% triticale diet had 2.4% less metabolizable energy (3240 vs. 3320 kcal/kg) than the control diet. Finishing pigs fed *ad libitum* will compensate for lower energy dense diets by increasing feed consumption. However, this was not observed. The pigs during summer fed the 80% triticale diet had 10.1% less ADG than those fed the control diet, whereas during winter, pigs fed the 80% triticale diet had only 3.0% less ADG. The greater fiber content of triticale may provide a feeling of satiety, reducing the urge for increased feed consumption to compensate for the lower dietary energy contents. Feedstuffs that are rich in fiber typically have a high heat increment, or heat of digestion. In hot environments, diets rich in fiber (high heat increment) decrease feed intake, thereby negatively affecting performance. Because the pigs were reared in hoop barns, it is likely some straw bedding was consumed. This may have furthered the fiber effect of triticale.

With similar feed intake and lower growth rate, gain:feed decreased ($P < 0.05$) as triticale inclusion increased. Increasing dietary crude fiber 1% may decrease gross energy digestibility by up to 3.5%. Probable consumption of bedding would have further aggravated this situation. Addition of fat or another energy dense dietary ingredient to the triticale diets may have supported similar growth gains and feed efficiency compared to the corn-soybean meal control.

Carcass Measures

There were no differences in carcass weight, BF measured at the 10th rib, LMA or percentage lean of barrows fed the control, 40 or 80 % triticale diets. There tended ($P < 0.10$) to be lighter carcasses with less BF during the winter than summer. Treatment had no effect on loin firmness, loin pH, or loin Minolta L*. Loin pH was higher during the summer than winter ($P < 0.05$). Loins from barrows were lighter and more yellow during the summer than winter, i.e., higher Minolta L* and b* values ($P < 0.05$). During the summer, loins from barrows fed the 80% triticale diet were more yellow than those from barrows fed the control or 40% triticale diet. During the winter, loins

from barrows fed the control diet had higher a* values ($P < 0.05$) than barrows fed the triticale diets. During the winter, barrows fed the control diet had higher loin b* values ($P < 0.05$), indicating more yellow loin coloration, than barrows fed the 80% triticale, with values from barrows fed the 40% triticale diet intermediate.

Meat Quality and Sensory Evaluation

Feeding triticale-based diets to barrows compared to corn-based diets in deep-bedded hoop barns had little effect on meat quality and sensory evaluation of pork during the winter and summer. During the summer, loins from barrows receiving the 40% triticale diet had the lightest color, loins from barrows receiving the control diet had the darkest color, with loins from barrows fed the 80% triticale diet being intermediate, as indicated by Minolta L* values. During the winter, loins from barrows fed the 80% triticale diet had the highest Minolta L* values, loins from barrows fed the control diet had the lowest L* values and loins from barrows fed the 40% triticale were intermediate. Fat from barrows receiving the control diet had lower Minolta L* values ($P < 0.05$) than those receiving the triticale diets during summer. There were seasonal effects on meat quality. Ultimate pH of loins was higher in the summer ($P < 0.001$) than winter. Loin chops had greater percentage of loin purge ($P < 0.05$) during the winter than summer. Shear force was greater in winter ($P < 0.05$) than summer, indicating more tender pork in the summer than winter. Japanese color scores were higher in the summer ($P < 0.05$) than winter, indicating darker loins. However, loin Minolta L* values were higher ($P < 0.01$) and b* values lower ($P < 0.05$) in the summer than winter, indicating lighter, less yellow loins in summer. Fat was darker ($P < 0.001$) and redder ($P < 0.05$) during the winter than summer, as indicated by fat Minolta L* and a* values. Sensory evaluation of loin chops from barrows showed loins to have higher scores for juiciness ($P < 0.001$) during the summer than winter. Juiciness scores were highest for loins from barrows fed the control diet, lowest for loins from barrows fed the 40% triticale diet and intermediate for loins from barrows fed the 80% triticale diet during the summer. Differences in tenderness, chewiness, pork flavor and off-flavor scores were not detected between seasons or treatments.

Fatty Acid Profile of Loins

Loins from barrows fed triticale-based diets had similar fatty acid profiles to those from barrows fed corn-based diets. During the winter, behenic acid (22:0) content of loins was greater from barrows fed the 80% triticale diet than from barrows fed the control diet and intermediate in loins from barrows fed the 40% triticale diet. All other fatty acid contents were similar between treatments. During the summer, the percentage of total lipids in wet tissue was higher ($P < 0.05$) in loins from barrows fed the control diet than the triticale diets. There were seasonal effects on fatty

acids profiles of loins from barrows finished in deep-bedded hoop barns. The percentage of total lipids in loin muscle during the summer was greater ($P < 0.001$) than winter. Loins had more oleic acid (18:1) during the summer than winter. Linoleic (18:2), 11-14 eicosadienoic (20:2) and arachidonic/eicosatrienoic (20:3/20:4) acid concentrations were greater ($P < 0.01$) in the winter than summer. Total monounsaturated fatty acids (MUFA) were greater ($P < 0.05$) in the summer than winter. Total polyunsaturated fatty acids were greater ($P < 0.01$) in the winter than summer. Season had no effect on total saturated fatty acids. There were more ($P < 0.01$) n-6 fatty acids during the winter than summer.

Season affected fatty acid profiles of loin chops from barrows in deep-bedded hoop barns. Percentage of total lipids in loins was greater during the summer than winter. This may be due to fat mobilization of pigs during winter to be used as an energy source for thermoregulation. During

the summer, MUFA content was greater and PUFA content was less than during the winter. Season did not affect SFA contents.

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Table 1. Composition of diets fed to finishing pigs in deep-bedded hoop barns, as-fed basis.

<u>Ingredient, %</u>	<u>Control^a</u>	<u>40% Triticale^a</u>	<u>80% Triticale^a</u>
Corn	85.00	46.50	8.50
Triticale	0.00	40.00	80.00
Soybean meal (48% CP)	12.91	11.53	9.64
Dicalcium phosphate	0.60	0.33	0.07
Limestone	0.90	1.05	1.20
Salt	0.34	0.34	0.34
Vitamin premix ^b	0.20	0.20	0.20
Mineral premix ^c	0.05	0.05	0.05
<u>Calculate analysis</u>			
Crude protein, %	12.90	13.60	14.10
Lysine, %	0.61	0.62	0.61
Ca, %	0.53	0.54	0.55
Available P, %	0.17	0.17	0.17
ME, kcal/kg	3320	3240	3160

^aContained 0.5 g/kg aureomycin chlortetracycline (Alpharma Inc., Fort Lee, NJ).

^bPremix supplied vitamins to meet or exceed NRC (1998) requirements for finishing pigs.

^cPremix supplied minerals to meet or exceed NRC (1998) requirements for finishing pigs.

Table 2. Amino acid content (percentage) of Trical 815 triticale, triticale and corn, as-fed basis.

<u>Amino acid</u>	<u>Trical 815 triticale^a</u>	<u>Triticale^b</u>	<u>Corn^b</u>
Arginine	0.57	0.57	0.37
Histidine	0.26	0.26	0.23
Isoleucine	0.36	0.39	0.28
Leucine	0.70	0.76	0.99
Lysine	0.37	0.39	0.26
Methionine	0.18	0.20	0.17
Cystine	0.27	0.26	0.19
Phenylalanine	0.49	0.49	0.39
Tyrosine	0.23	0.32	0.25
Threonine	0.32	0.36	0.29
Tryptophan	0.12	0.14	0.06
Valine	0.51	0.51	0.39

^aAmino acid analyses conducted by University of Missouri Experiment Station Chemical Laboratories, Columbia, MO.

^bValues from NRC (1998).

Table 3. Performance of finishing pigs fed triticale-based diets in deep-bedded hoop barns during summer and winter^a.

<u>Item</u>	<u>Summer</u>			<u>Winter</u>		
	<u>Control</u>	<u>40%</u>	<u>80%</u>	<u>Control</u>	<u>40%</u>	<u>80%</u>
No. of pigs	40	40	39	39	39	40
No. of pens	4	4	4	4	4	4
Start wt, kg	72.8 ^o ± 1.87	73.1 ^o ± 1.87	70.8 ^p ± 1.87	72.3 ± 1.87	72.4 ± 1.87	71.2 ± 1.87
End wt, kg	116.5 ^u ± 2.17	114.5 ^v ± 2.17	110.2 ^w ± 2.18	117.3 ^r ± 2.18	116.3 ^s ± 2.18	115.1 ^t ± 2.17
ADG, g/d	892 ^u ± 18	846 ^v ± 18	802 ^w ± 18	930 ^r ± 18	901 ^s ± 18	904 ^s ± 18
ADFI, kg/d	3.51 ± 0.18	3.49 ± 0.18	3.53 ± 0.18	3.91 ± 0.18	4.11 ± 0.18	4.35 ± 0.18
Gain:feed g/kg	254 ^o ± 7	243 ^{op} ± 7	227 ^p ± 7	239 ^r ± 7	221 ^{rs} ± 7	209 ^s ± 7
BF, mm ^b	18.3 ^o ± 0.06	17.6 ^p ± 0.06	17.0 ^p ± 0.06	17.7 ± 0.06	20.5 ± 0.06	19.6 ± 0.06
LMA, cm ^{2,b}	47.5 ^o ± 1.72	45.5 ^{op} ± 1.72	43.4 ^p ± 1.73	47.6 ± 1.73	44.8 ± 1.73	45.0 ± 1.72

^aSummer = April through September; Winter = October through March.

^bFrom ultrasound scan data.

^{opqrst}Within a season, LS means without a common superscript letter differ ($P < 0.05$) during summer (^{opq}) or during winter (^{rst}).

^{uvwxyz}Within a season, LS means without a common superscript letter differ ($P < 0.01$) during summer (^{uvw}) or during winter (^{xyz}).